feature is the great and almost interminable palm forests, which, singularly enough, in the Chaco are a sure indication of marshy lands subject to inundation, although in the province of Entre Rios, and other parts of the world, they are the exact contrary. On the northern and eastern borders of the River Bermejo the Central Chaco rises sensibly, as if to form a barrier to the waters of that river in their easterly progress. The Chaco Austral of the Argentine is the most favoured in natural riches of the three great sections. Its surface rises gradually from the Paraná River, and is intersected by several small streams, which are even now useful as a means of water-carriage to the many colonists settled along their courses; after rising thus up to the parallel of 25° 40′ S., the ground dips towards the valley of the San Francisco, sending its waters with those of that river to the Bermejo, sometimes in untimely floods. This depression extends across the Central into the Paraguayan Chaco, taking in the sections of the two rivers that are subject to yearly overflows between long. 61° and 62° W. of Greenwich, thus making a point of analogy between the two. The Austral is favoured with extensive primæval forests, notably that on the north-western border extending into Salta and covering a superficies of many hundreds of miles, quite unexplored, and sometimes designated by the name of "impenetrable." The principal water-courses of these territories are the Pilcomayo and Bermejo, which are undoubtedly destined to become highways of commerce. The waters of these rivers differ in colour, those of the Pilcomayo being dark and sometimes brownish, and those of the Bermejo red, as its name indicates; both are long, narrow, and tortuous, as are most of the interior rivers of the La Plata system; both run in a general south-east direction, preserving a remarkable parallelism throughout their entire course, running distant from each other as nearly as possible 180 miles. Neither of these streams receives tributaries of any kind over the greater part of their course, and their waters are consequently subjected to a great and constant drain from evaporation, in a climate whose average temperature is 80° F., as well as from absorption by the deep alluvial covering overlying the compact argillaceous bed, which is a geological characteristic of the whole Chaco subsoil. The impermeability of this bed probably arrests the effect of absorption, and in a great measure accounts for the non-diminution of the wealth of waters delivered into the Paraguay; such a geological formation may also account for the saline properties of the waters found in the Chaco, wherever wells have been made. The density of the Bermejo water is greater than that of the Pilcomayo; the amount of sediment it brings down is enormous, and it is deposited with such extraordinary rapidity that it cannot but be considered a peculiarly strong feature of the mechanical work of this river, by which its geological formations are rapidly made, and, indeed, unmade as well; this swift precipitation of its detritus, which it replaces by an increasing abrasion of the banks, may be caused, to some extent, by the quantity of salt contained in its water. This constant precipitation goes on in the Bermejo, even when at its height, and when in the exercise of its greatest carrying power, with a speed quite equal to the square of its normal current; a fact which would seem to say that its currents are swifter on the surface than over its bed. Captain Page has seen this river eat away an entire point of land, and, by way of compensation, deposit, just a turning below, an amount of detritus sufficient to form a similar promontory, which, in one season of low water, became covered with a thick and luxuriant growth of red willow. The Pilcomayo—the Piscumayu, as it is called in the Quichua tongue, signifying Bird River—is to a great extent unknown. The section that is *quite* unknown, and that is surrounded by a certain mythical halo which it will be a geographical triumph to dispel, is that comprised between long. 61° and 62° W., and the parallels of 22° and 23° S.; the river at this point was said, by theorists who forgot to account for its reappearance immediately below, to disappear altogether. Captain Page then gave an historical sketch of the various expeditions which have explored the Gran Chaco, concluding with an account of an expedition in a steamer up the River Bermejo, which he himself led, amidst many dangers from banks, and snags, and wrecks, as well as from the widespread flood that suddenly overtook him.

WITH the first number for 1889 a useful modification has been introduced into *Petermann's Mitteilungen.* For the last few years, in addition to the classified list of geographical publications each month, there has been a separately paged supplement containing critical analyses of the more important works. These were often carried to such length that many of the notices were from six to twelve months behind date. Now, the two lists are to be amalgamated, the notices are to be greatly reduced in length, and thus it is hoped that new works in the various departments of geography will be promptly made known to the readers of the *Mitteilungen.* In the first number of this year is an important paper on valleys of erosion, by Dr. V. Hilber. The paper consists mainly of an analysis of the nine theories that have been advanced to account for the formation of such valleys. The author himself favours the regression theory, according to which valleys have mostly been formed by retrogression, through the erosion of a river from its mouth backwards.

CAPTAIN VAN GÈLE, the explorer of the Mobangi-Wellé, was to leave Antwerp on the 29th for the Congo, to undertake a special mission. He is accompanied by Lieut. Le Marinel, Lieut. De Rechter, and M. Ferd. Meunier, as naturalist.

M. MAUREL, who has explored French Guiana, recently described the results of his observations and investigations to the Geographical Society of Toulouse. From the orographical point of view, he stated, French Guiana comprises four zones, rising in stages to the Tumac Humac Mountains. The first consists of a broad band of alluvial country. The second zone is hilly, covered throughout by a series of hillocks and bluffs, not exceeding 650 feet in height, and frequently separated by shallow valleys. The third zone M. Maurel describes as mountainous, with an irregular surface, abrupt slopes, and deep valleys. The Tumac Humac chain constitutes the fourth zone, and it rises by a series of gradations to a height of about 4000 feet. M. Maurel has collected a number of flint objects, which he believes belonged to a pre-historic race that must have inhabited the country before the alluvial period. He accounts for the present formation of Guiana by two long-separated volcanic outbursts, acted on subsequently by a large river, which he believes gave origin to the deposits of the first zone.

MR. J. Y. BUCHANAN, PROF. A. H. KEANE, AND MR. J. T. WILLS, are candidates for the Lectureship in Geography at Cambridge, vacant by the resignation of Dr. Guillemard.

THE Russian Geographical Society has just brought out, as an appendix to the nineteenth volume of its Memoirs, an atlas containing all the measurements made by A. Kaulbars in the delta of the Amu-daria. These measurements, which will be invaluable to those who may hereafter study the changes going on in the delta of the great Central Asian river, could not be embodied in M. Kaulbars's capital work "The Old Beds of the Amu," published by the Society in 1887. Now they are given partly in the atlas (on the scale of 1 : 1,500,000), and in full in the text which accompanies it.

THE PRESENT STATE OF SEISMOLOGY IN ITALY.[1]

THIS group of papers affords the reader a very fair means of forming a mental estimate of what Italy has been doing to study her earthquakes during the last year or eighteen months.

Signor E. Brassart, for some years the Mechanical Constructor of the Central Office of Meteorology and Geodynamics, has produced a seismoscope in which a small slug perched on a thin column was overturned by the earthquake, and fell into an umbrella-like balance-pan surrounding the peg. In this way the direction of the shock was supposed to be indicated by the fold in which it fell, and its weight disturbed the equilibrium of the balance, which by making contact gave notice of the shock. Many of these are at present in use in Italy. A recent improvement is to suppress the balance, the contact is made by the slug being caught between the supporting style and surrounding umbrella-shaped grooves. The author of the paper experimented on earthquake alarms for vertical shocks, and found that, with three wire spirals, two supporting different weights and one without, the last gave less repeated oscillatory movements after the shock, returning more quickly to rest; and he therefore suggests this as an improvement on the old spring and bob seismoscope.

---

[1] "Sismoscopi o Avvisatori Sismici," Ermanno Brassart. "I Sismometri Presentemente in Uso nel Giappone," esaminati e descritti da Ermanno Brassart; con proposta di un Sismometro di Nuovo Modello. "Il Sismometrograph a Tre Componenti con Una Sola Massa Stazionaria," Nota di Ermanno Brassart. "Sulla Sistemazione delle Osservazioni Geodinamiche Regolari," del Prof. Giulio Grablovitz. "Relazione della Sottocommissione Incaricata di Studiare alcune Proposte per l'Ordinamento del Servizio Geodinamico nell' Italia Meridionale e nelle Isole," del Prof. T. Taramelli. "Relazione alla R. Sottocommissione Geodinamica sulla Distribuzione delle Aree Sismiche nell' Italia Superiore e Media," del Prof. T. Taramelli. "Il Terremoto nel Vallo Cosentino del 3 Dicembre, 1887," Studio del Dott. Giovanni Agamennone.—All these papers are published in the *Annali dell' Ufficio di Meteorologia e di Geodinamica*, vol. viii. Parte 4, Anno 1886. (Rome, 1888.)

"Alcuni Risultati di uno Studio sul Terremoto Ligure del 23 Febbraio, 1887," Nota di T. Taramelli e G. Mercalli, *Rendiconti d. R. Accad. dei Lincei*, vol. iv. fasc. 1. (Roma, 1888.)

The next point discussed is whether it is preferable to stop or start a clock at the moment of an earthquake, and is in favour of starting one, as the few minutes between the shock and the arrival of the observer could afford little time-error, whereas there is no means of correcting the time-error of a clock stopped by the shock.

Following an observation of Prof. J. Milne on the facility with which light objects, such as pens, pencils, &c., when propped up nearly vertically, fall by the slightest movement, the author has constructed a seismoscope. A long thin bar, standing in a concavity, is supported by a small prop that can be regulated so as to put the bar almost in a vertical position, which is surrounded by an isolated ring of brass. On the occurrence of a shock, the bar falls and completes a circuit with the brass ring so as to ring a bell, start a clock, &c. Experiments made by the inventor and Prof. Tacchini showed the extreme sensibility of this seismoscope compared with others placed on a marble wall-bracket upon which small weights were allowed to fall. Drawings and descriptions are given of a method of using this seismoscope to start a clock, the pendulum of which is retained ready to vibrate by a short catch. The ring surrounding the falling bar is supported on a jointed base and the falling bar displacing it, and acting on a system of jointed levers the catch falls out of the way of the clock pendulum.

Next, Signor Brassart alludes to the different ideas current about the best method of connecting seismic apparatus to the ground, and shows the necessity of a series of experiments to determine this by using stakes, walls, &c., and employing seismographical instruments of different types.

In the next memoir by the same author, a description and drawings of the principal apparatus used in seismological research in Japan is given, together with a criticism of each. He concludes the review of these instruments by pointing out that it is only those in which a pendulum is employed, together with those possessing a rolling base, either spherical or cylindrical, that do not require adjustment, beyond rendering the base horizontal. His own choice would be a vertical pendulum, because not only does it not require adjustment and is constantly ready to indicate the shock, but is always in the same condition; and then adds, "In other arrangements it is possible greater stasis or neutrality of the mass is obtained, but notwithstanding that, for the above-mentioned reasons I should show a propensity for pendulums." This is a preference I fear few other seismologists would share with the author, since he undoubtedly alludes to vertical forms. The floating seismograph of Gray is favourably mentioned, but troubles from evaporation of the liquid, &c., pointed out. This is similar to the opinion expressed by the writer of this article, some years since, in a paper on seismographs published in NATURE.

Signor Brassart then proceeds to suggest an instrument consisting of an annular pendulum suspended by a silken cord 1 metre long, attached at its upper end in the middle of another horizontal cord made taut by side screws in the frame. In the middle of the bob, near the centre of gravity, is a pin which slides in two slots placed at right angles to each other. These slots are cut in the ends of levers of the first order, one being bent at right angles so as to bring the opposite ends of the levers side by side, to which are attached writing needles. These are made to trace on a smoked glass plate held on a truck, which by a seismoscope is liberated and drawn along at a uniform and known rate by a clock. This proposition was soon carried out with some modifications, and at the end of the paper is an appendix describing it. The changes of design consist of the suspending silk cord being attached to a stage supported on three vertical cork cylinders, the object of which is not very evident, except, perhaps, to absorb a part of the vertical component. This latter is registered by a Gray's compensated bob attached to the same frame, and by means of levers made to trace side by side with those of the two horizontal component styles on the same plate, or, as the author suggests, in some suitable cases upon an endless band of paper. This seismograph has many defects which it will be more convenient to discuss later on. This paper is dated December 1887.

It has doubtless been the ambition of most inventors of seismic instruments to be able to register the three components of an earth-movement employing but one steady-point or mass. Anyone who makes such an attempt, however imperfect be his result, deserves much credit for trying such a herculean feat in mechanical construction.

Signor E. Brassart's later production is described in February of this year, and, in so far as the registration of the horizontal components goes, is quite similar to that described in December 1887. Inserted in the suspending cord is a spiral spring inclosed in a tube, which consequently also allows the bob movement up and down. The peg or rod then slides in the slots of the horizontal component levers, is prolonged downwards a suitable distance, and terminates in a ball, which is engaged in a short tube or cup at the end of a bar. A gimbal is a mechanical arrangement by which a bar supported in its centre can rotate around any theoretical axis in the horizon of the gimbal, whilst any motion along a line normal to the horizon or plane of the gimbal would be resisted; or, if the gimbal be suspended to a lever, this will be moved in proportion to the vertical movement applied to the gimbal arrangement. (The writer of this article believes the gimbal was first applied by himself in seismological instruments, but he is open to correction.)

Signor Brassart takes advantage of this, and makes the sphere at the end of the peg from the pendulum, form a ball-and-socket joint with the tube or cup bar of the gimbal arrangement, which is supported horizontally at the end of a lever. Now all horizontal excursions of the peg, joint, and gimbal bar, are quite free, but vertical excursions will disturb the whole gimbal system with its lever, the motion of which by suitable mechanical arrangements is traced by the side of the horizonal component styles.

It will be convenient now to examine the favourable points and disadvantages of these instruments. In the first place, we have the well-known defects of the vertical pendulum for registering the horizontal components of an earthquake. Then, the author's method of the peg sliding in the two slots of levers introduces an amount of friction, even where the finest workmanship and materials are adopted, as to modify the results to an important extent. In regard to the gimbal arrangement, that answers perfectly during vertical without horizontal movement; but the moment that lateral displacement takes place, the bar of the gimbal, and the pendulum length, form two sides of a triangle instead of a straight line. On the principle that two sides of a triangle are always greater than the third, the more the horizontal components are, the less would the vertical component be registered. And even there is a point in which the motion of the pendulum bob would simply resolve itself in a greater tilt of the gimbal bar.

The next study by Prof. G. Grablovitz is a kind of programme of seismological observations to be made in Italy. The paper shows a clear conception of the known or probable relationship of different seismic phenomena, and apparently the best methods to adopt for their study. One most favourable point about the author's writing is a total absence of that long-winded style, charlatanism, and seismic magic, which has characterized the writings of many Italian seismologists up to quite recently. Very little, however, is new: similar suggestions may be found scattered through the writings of many other seismologists, and part, at least, were thrown out by the writer of this article in many of his papers relating to Ischia. It is, in fact, in organizing the new observatory on that island by Prof. G. Grablovitz that has led that gentleman to the considerations contained in his paper. From observations made with the mercury cup in the temporary Ischian Geodynamic Observatory, passing carriages and numbers of people could be detected at a distance of 100 metres; therefore the author considers this as the minimum distance of isolation such an observatory should possess.

The next is a report of a sub-committee, drawn up by Prof. T. Taramelli, dated December 1886. It consists of a review of the principal earthquakes that have affected different regions of Southern Italy, and the means then in existence for their study. This was preceded by another report referring to Northern and Central Italy. The author opens his report by discussing the views of different writers as to the causes of earthquakes, without adding in any way to those views. Chapter ii. is a review of the earthquake parts of Italy referred to in the report, together with an attempt to separate the country into seismic provinces, a work already in part carried out by Mercalli, and where observatories are wanting to suggest the establishment of them. Appended to this memoir is a map of Italy coloured in nine tints, showing the seismic intensity in different regions. If the reader compare this with a geological map of the country, he will be struck with the relationship of earth-movements and the rocks. We notice intense foci near Sienna, north of Florence, and the alluvial flats of the mouths of the Po, another in Umbria, and a very intense one between Aquila and Solmona, where the Apennines reach their greatest elevation. There are the two volcanic centres of Naples and Melfi, with the intervening of Benevento and Ariano, a district in which comparatively recent rocks are much metamorphosed, whilst to the south-west of Potenza we observe a large but only moderately intense focal area. The toe of the Italian boot looks very dark with the two intense centres of Cosenza and Aspromonte, together with the Messina district in Sicily. In these we have granite, gneiss, and other crystalline rocks, covered chiefly by more or less friable Tertiary deposits, much eroded into many narrow deep valleys, and sharp crumbling intervening ridges. One cannot but be struck by the striking relationship between the distribution of seismic areas and the alluvial flats, the volcanic regions and more active points of mountain-building in the geologically-speaking young country of Italy. In fact, this map constitutes the most important part of the report.

The last two memoirs are descriptive in character, dealing with the two recent destructive earthquakes. Of these two, the first, by Dr. J. Agamennone, refers to the earthquake which occurred on December 3, 1887, in the Cosenza Valley. Besides the topographical, a geological map is given, with a description from which we learn that this strip of mountainous land lying between the Gulfs of Taranto and of Policastro is composed principally of granite and allied rocks with gneisses and schists. The depression constituting the valley is filled by clays, sand, marls, and other more or less incoherent rocks of Tertiary age, which have been eroded by innumerable side valleys into pinnacles, and tongues of land with more or less perpendicular sides very liable to slips. Bisignano, which suffered most severely, is situated on some of these pinnacles or almost isolated tongues of molasse. Although the town has been destroyed by nine or ten earthquakes, many of these had their foci at some considerable distance. This last earthquake occurred during a barometric maximum corresponding to a marked centre of high pressure that crossed Europe from December 1–3, and three days after full moon. The author could find no relationship between increase or decrease of microseismic movements in Italy and this earthquake. As there were probably three shocks, the first being comparatively feeble, the people had already escaped from their houses when the second arrived, so that, comparatively to the ruin, few lives were lost. These are the results of the statistics: houses down or threatened ruin, over 900; deaths, 22; wounded, 60; and damage done to the value of 1,000,000 lire.

It appears that here stone must be brought from some distance, and building materials are very dear, hence bad construction and ruin. This but too well recalls the appalling scenes that passed under the eyes of the writer of this article after the earthquakes of Ischia [1] which might have been far less destructive, had it not been for the horribly bad walls, &c.

From the exceedingly incorrect time kept and the few approximately accurate records, the calculations afford for the *velocity of propagation* from 650 to 3300 metres per second.

The author shows that the epicentre was near the station of Mount Grascano, and that the greatest damage was on the loose unsupported friable rocks resting inclined against the sloping faces of the older compact rocks—conditions of effect identical with what occurred in the great Calabrian earthquake of 1783, and noticed by Mallet in 1857. The intensity of this earthquake the author calculates, on somewhat flimsy grounds, at eleven times less than the Andalusian, and four times less than that studied by Mallet in Italy in 1857. The sound seems to have been communicated to much greater distances through the compacter and more elastic rocks than through the loose detritic deposits. What, however, is strange, is the manner in which the author talks of one shock being subsultory and another, in the same locality, as undulatory, as if they were two entirely different kinds of earthquakes.

In fine, we pass to the consideration of the Ligurian earthquake of February 23, 1887 (described by Prof. Taramelli and Mercalli), which drove so many people away from the towns of the Riviera. The first eight pages are devoted to the geology of the district, which may be said to be composed of a range of compact fairly elastic rocks close to the shore-line. The valleys that incise the cliff along the coast extend not only to the sea line, but some distance beneath the water, whilst near the coast they are partly filled by platforms of late Tertiary, and very incoherent deposits. It is on these small somewhat triangular planes that most of the towns are met with. The region is one of the most disturbed by earthquakes of Upper Italy, no less than twelve, more or less destructive, occurring since the thirteenth century.

The authors sent out 1100 circulars to different localities, and from the answers were able to obtain much information. It appears that, as on former occasions, slight shocks were felt over the whole district, and preceded the great one, no less than four occurring during the previous night to February 23, 1887. The area affected extended southwards to Rome, Mount Ferrù (Sardinia), east to Pordenone, west to Perpignan, and north to Lyons and Basle. The mesoseismic area was crescentic in shape, 100 miles long between Mentone and Albissola. The form was due to the focus being beneath the sea, and to the region occupied by the elastic crystalline rocks. The effects of geological structure in affecting the limitation of isoseismal areas was beautifully illustrated in the Ischian earthquakes described by the reviewer. It is not customary to call the region above mentioned the mesoseismal area, which should be limited to that space around the epicentre and above the focal area: a better definition would be that of almost total destruction. The zone of severe injury extended to the Langhe of Piedmont and Astignano. The limits of severe shaking reach Turin and the lower Canovese, whilst the earthquake was strongly felt as far as Como, Arona, Parma, Leghorn, Marseilles, and nearly all of Corsica.

The main shock seems to have had two maxima, and to have lasted about 30 seconds. The authors calculated the *velocity of projection* at 9·4 m. at Oniglia, 3·53 m. at Faggia, and 4·7 m. per second at Nice. As in other cases of localities not epicentral, the rumble preceded the shock, the more, the farther the observer was from the focus.

Azimuths point to the epicentre being 15 miles from the beach, midway between Oniglia and San Remo, which is confirmed by the isoseismals being concentric to a point 20 kilometres south of Porto Maurizio. The shock appears to have started at about 6.19 a.m. The velocity of propagation was calculated at 1452 m. per second westward, and 584 m. per second towards Genoa: this the authors consider to be due to a main and secondary focus, whilst the depth obtained from emergence angles appears to be 18 kilometres. Little disturbance of the sea occurred, but it is said to have remained at a lower level for some days at Loano and Porto Maurizio. Dead fish of deep-sea character were found along the coast some days after. No meteorological phenomena of importance were noted, but strong telluric currents were set up at the moment of the earthquake. After nine minutes, another destructive shock occurred, another at 8.53 (M.T. Rome), and in the ruined area there occurred another twenty-two slight shocks, and others continued to occur with diminished force to March 11, so that at Savona fifty were perceptible in all.

The first three earthquakes killed 640 persons, and wounded as many, and the damage in the provinces of Porto Maurizio, Albenga, and Savona, was valued at 21,500,000 lire.

The greatest damage occurred on thin layers of incoherent rocks superposed on the more elastic and crystalline ones, at sharp boundary lines of different rocks, and unfavourable topographical positions. The effects were augmented by bad and unscientific construction of the houses, or badly repaired buildings, that have suffered in former shocks.

In this article, already of inordinate length, fair justice has hardly been done to the works reviewed, but the reader will see that Italy is awaking to her duty towards humanity and science in organizing the study of her seismic phenomena, and shaking off that conservatism and isolation which ruled her in this department up to the year after the great Ischian earthquake.

H. J. JOHNSTON-LAVIS.

---

[1] H. J. J.-L., "Monograph of the Earthquakes of Ischia: a Memoir dealing with the Seismic Disturbances in that Island from Remotest Times, with Special Observations on those of 1881 and 1883." (Naples: Furcheim, 1885.)